Mitigation of delay and scintillation effects using MIDAS

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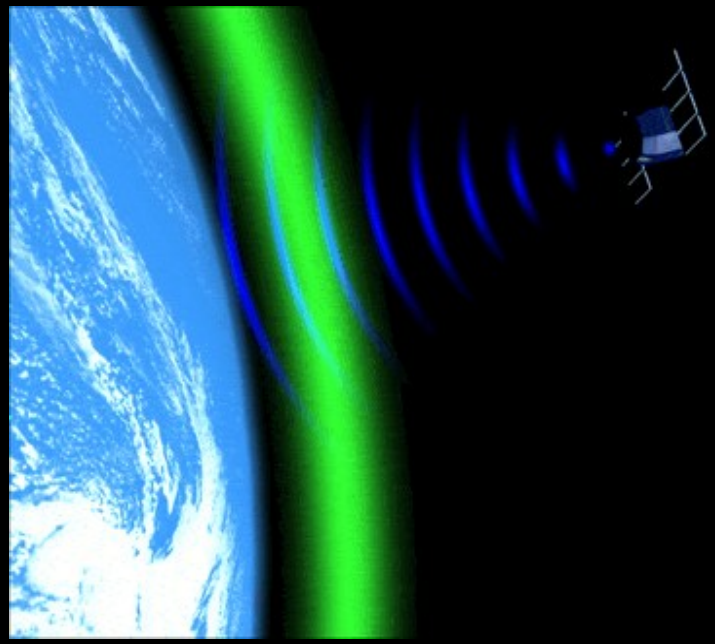
The Ionosphere



The ionosphere causes equal delay on the GPS code and advance on the carrier phase, proportional to:

- the inverse of the square of the frequency
- the Total Electron Content along the ray path

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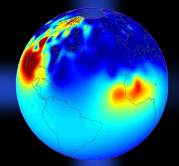
Outline



The ionosphere delays GPS signals

- When not properly compensated this delay is the cause of most of the positioning error

- This delay can be compensated by
  - direct measurement with a dual-frequency receiver
  - a model of the ionosphere, for example Klobuchar or IRI
  - a real-time map of the ionospheric delay

Comparisons between these methods over Europe are made for the last solar maximum.

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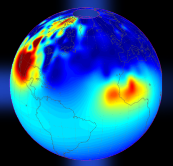
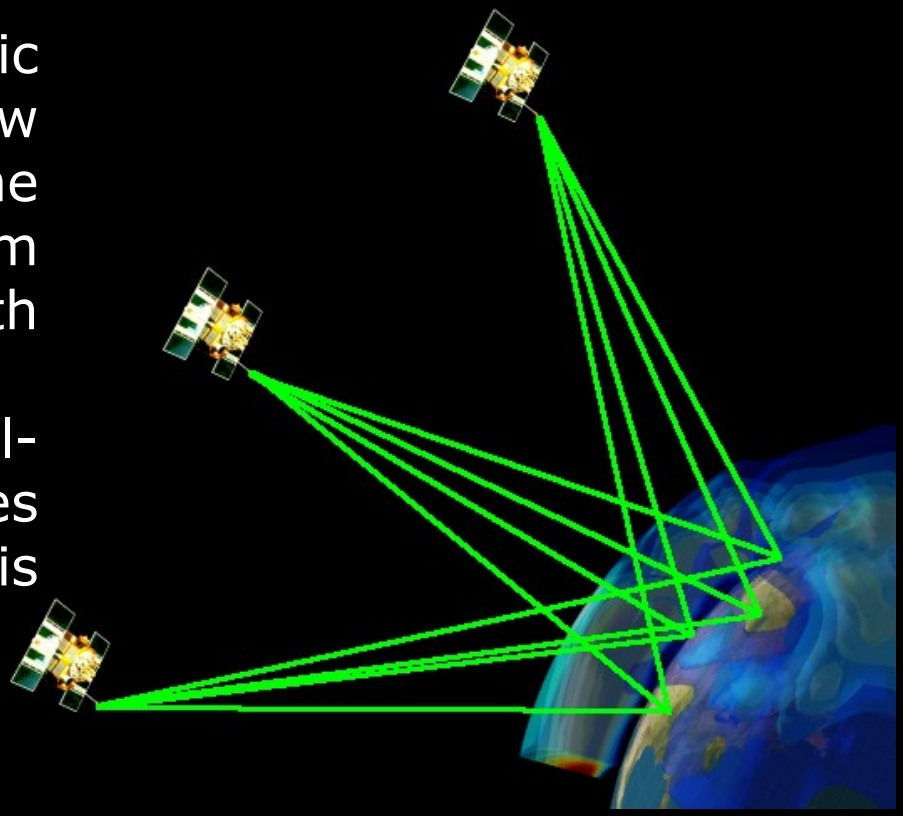
4D Tomography



MIDAS (Multi Instrument Data Analysis System):

- downloads RINEX data from dual frequency receivers
- with a tomography from the phase advances on L1 and L2, gives a 4D image of the electron density in the ionosphere

- Real-time: The tomographic inversion takes a few minutes. A near-real-time (10 min prediction) system would be achievable with constant data streaming.
- Predicted: The near-real-time imaging requires 40 min prediction. This is limited by data latency.



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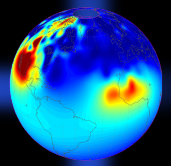
Pseudo-range



The *P* observable is the sum of :

- the true range ***r***
- the receiver clock error $c\Delta_r t$ (specific and relativistic)
- the satellite clock error $c\Delta_s t$, from the ephemeris
- when working in the ECEF frame, the Sagnac distance r_s
- the ionospheric code delay or phase advance ***I***
- the tropospheric delay ***T***, calculated from a model
- noise, multipaths and negligible relativistic terms ε

$$P = r + c\Delta_r t + c\Delta_s t + r_s + I + T + \varepsilon$$

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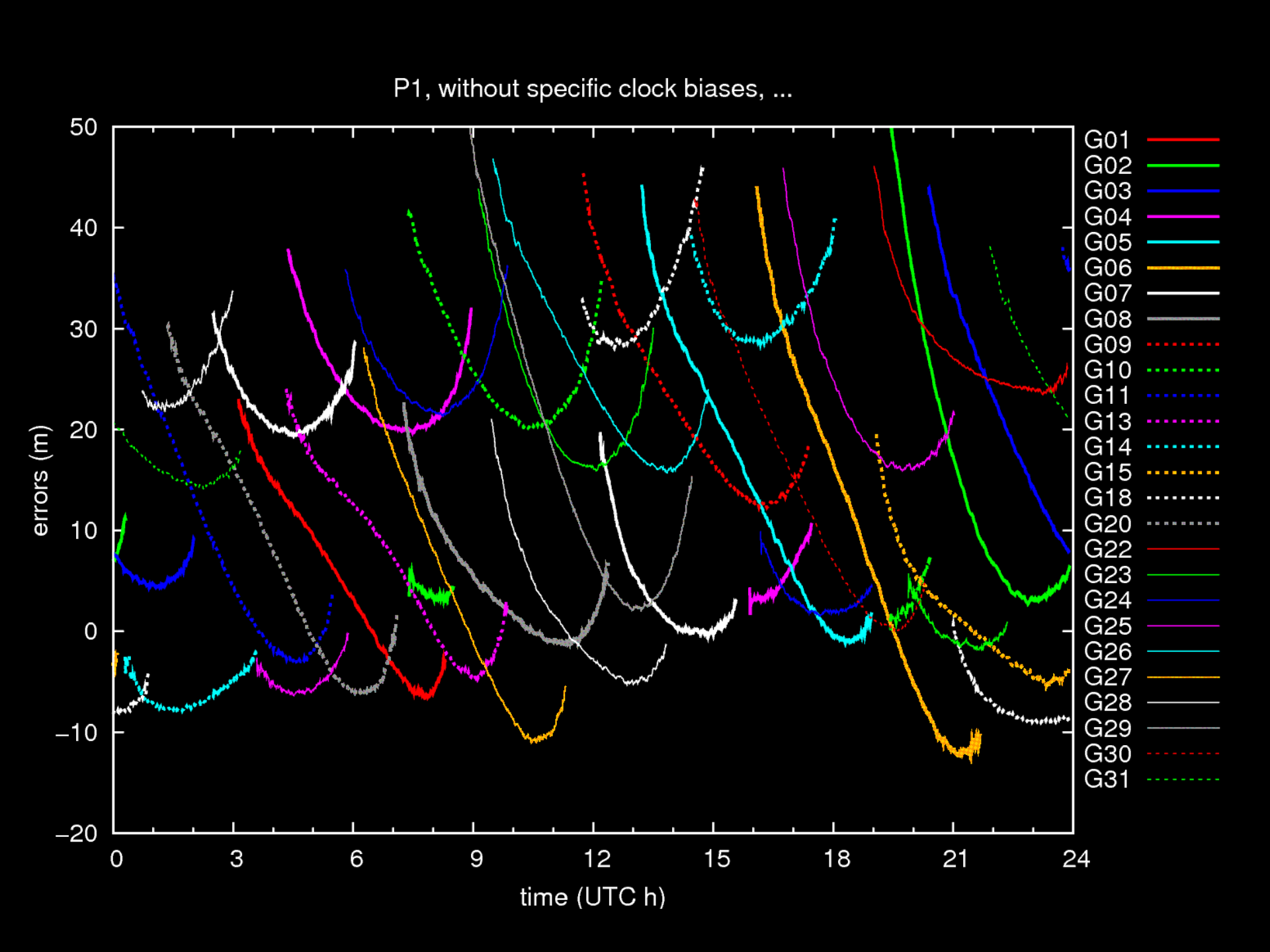
Acknowledgements : IGS ephemeris


P1, without specific clock biases, ...
errors (m)
50
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30
20
10
0
−10
−20
0
3
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9
12
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24
time (UTC h)
G01
G02
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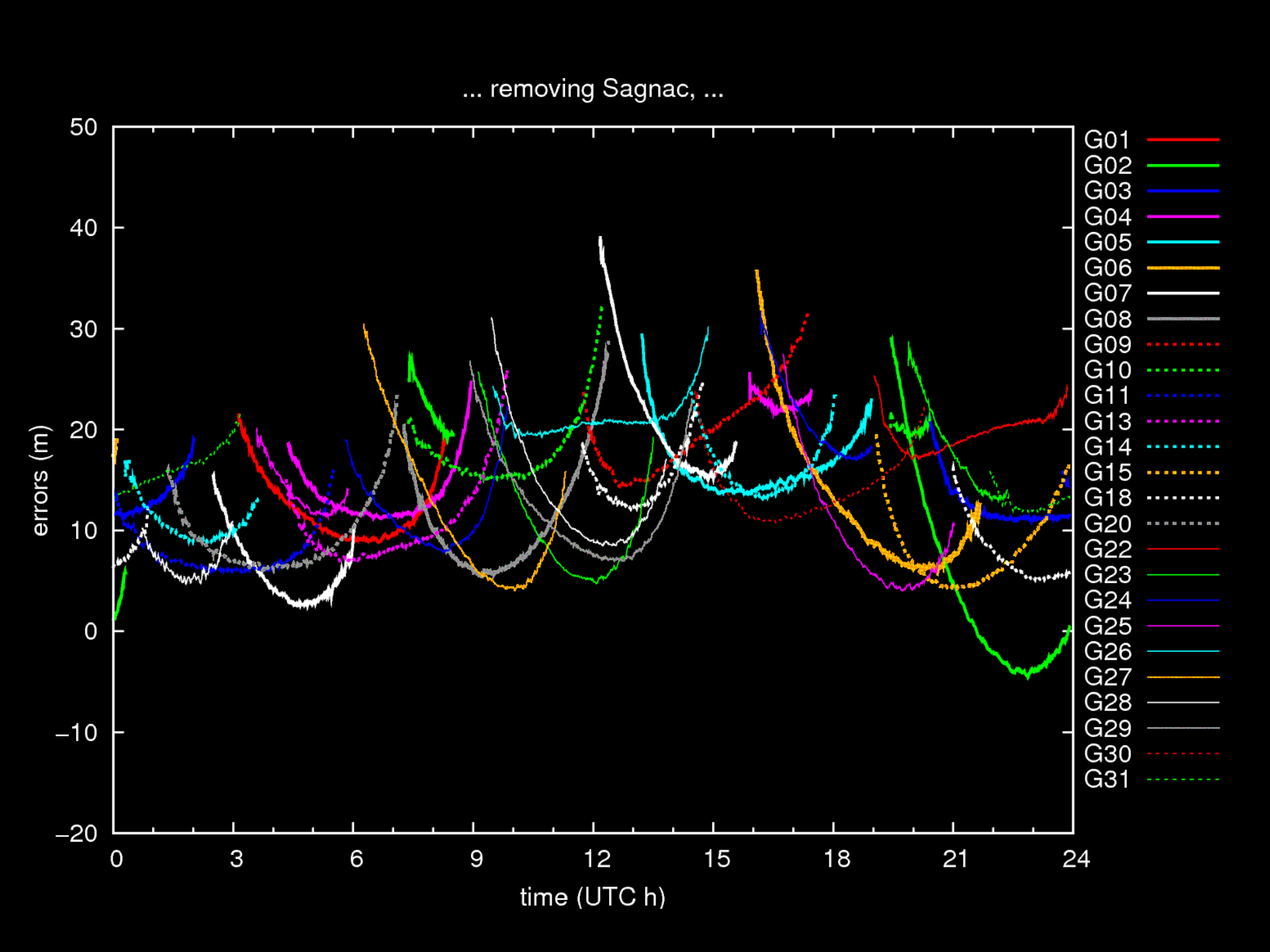
... removing Sagnac, ...
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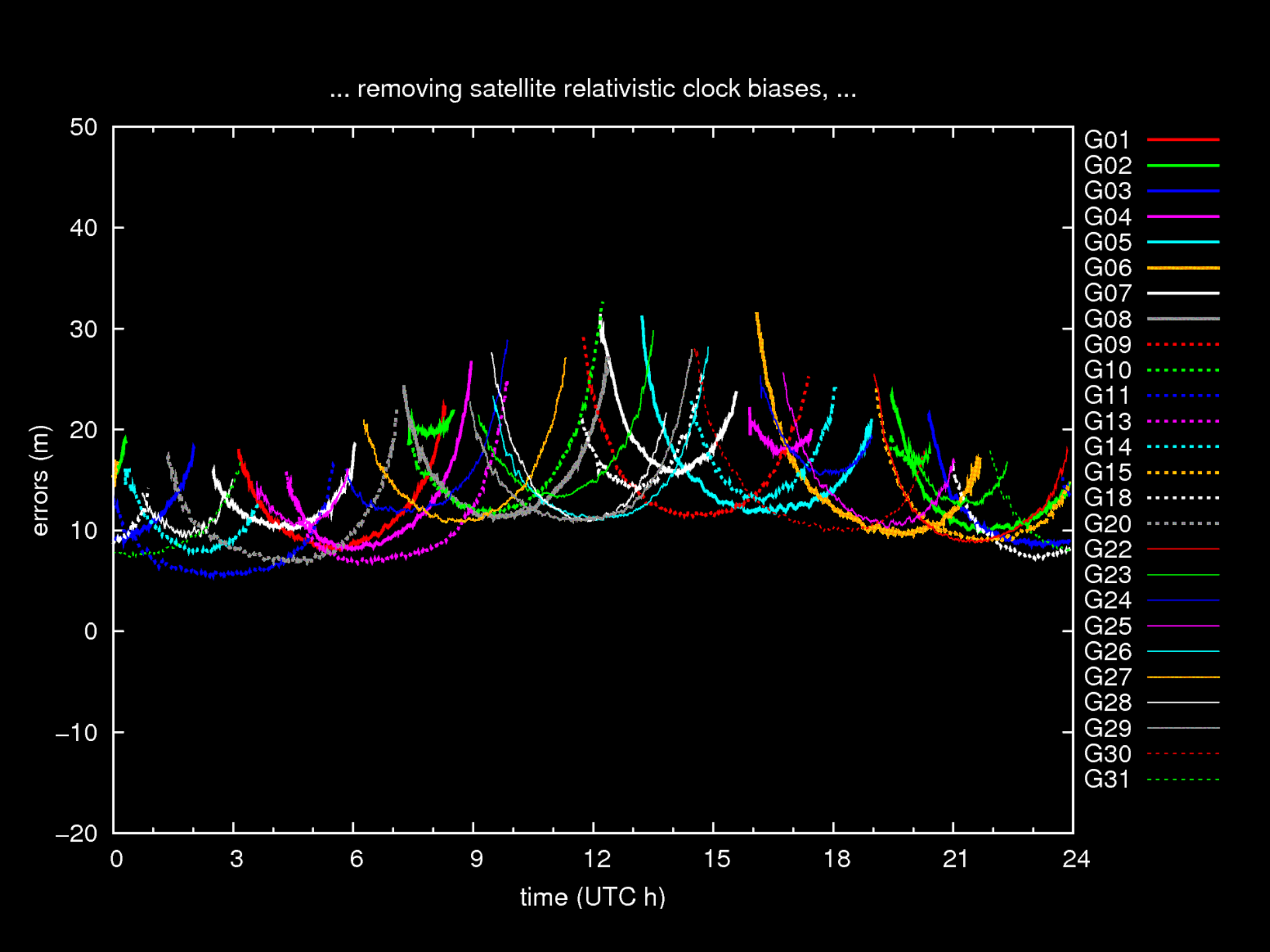
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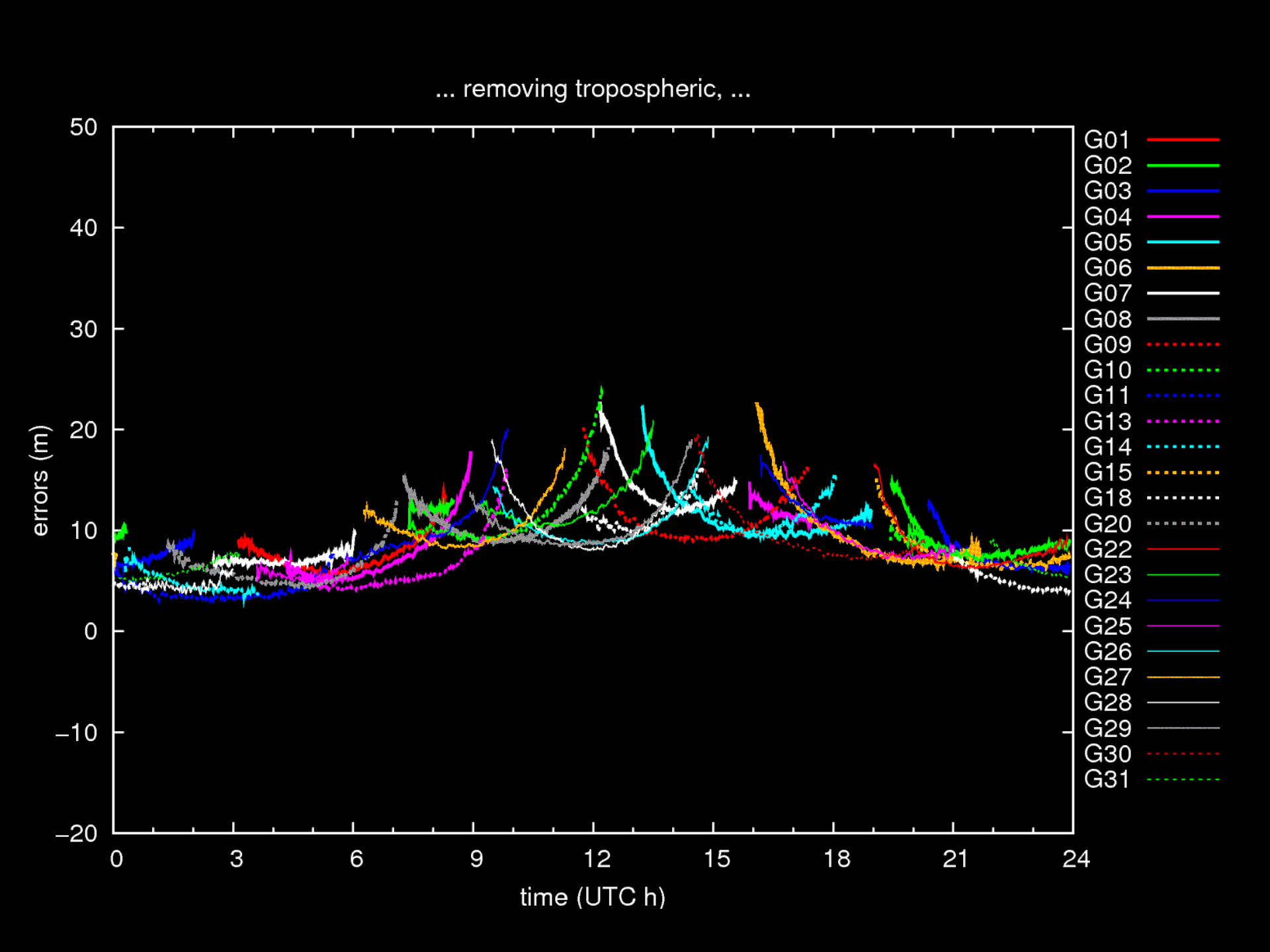
... removing tropospheric, ...
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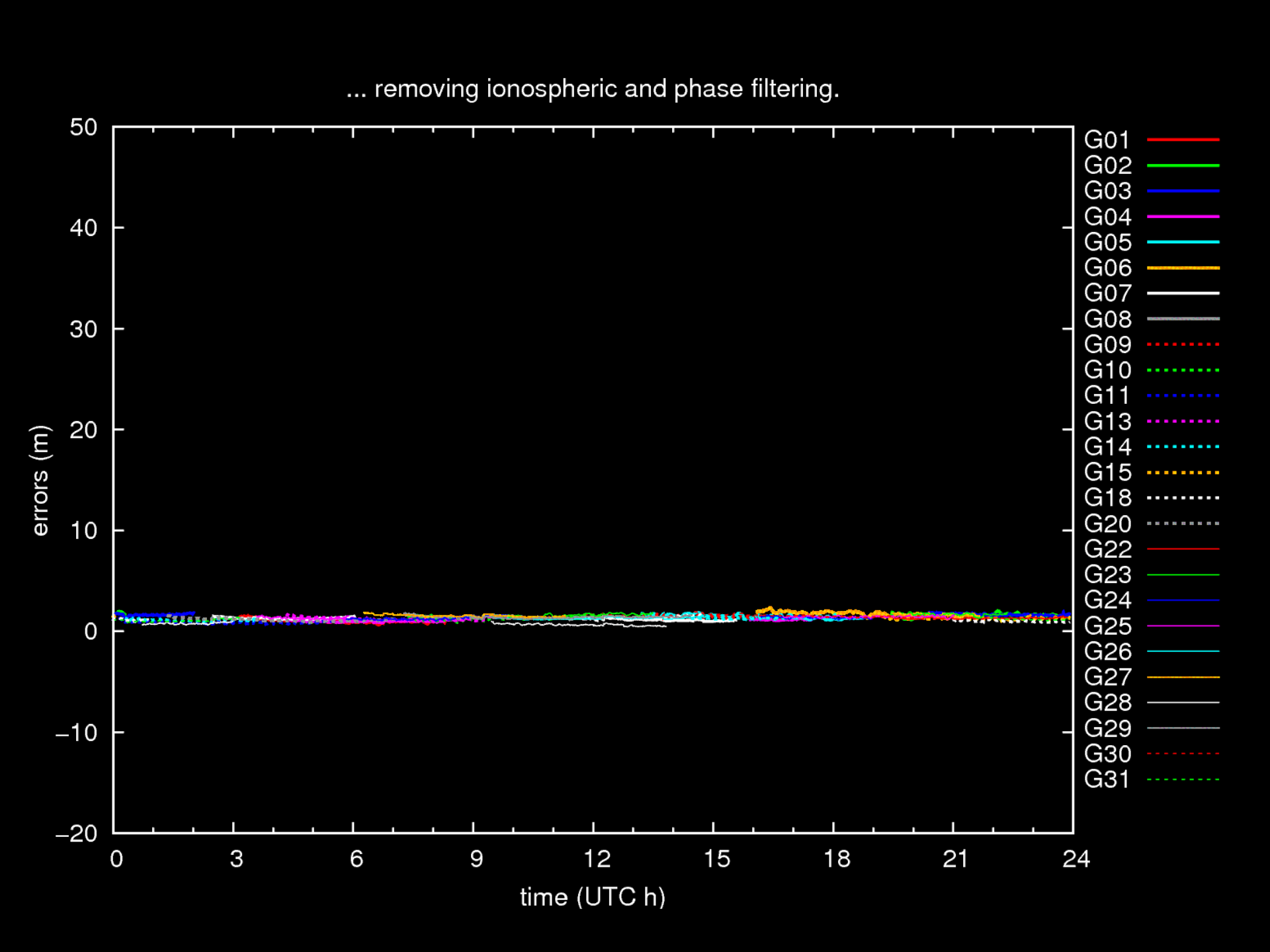
... removing ionospheric and phase filtering.
errors (m)
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time (UTC h)
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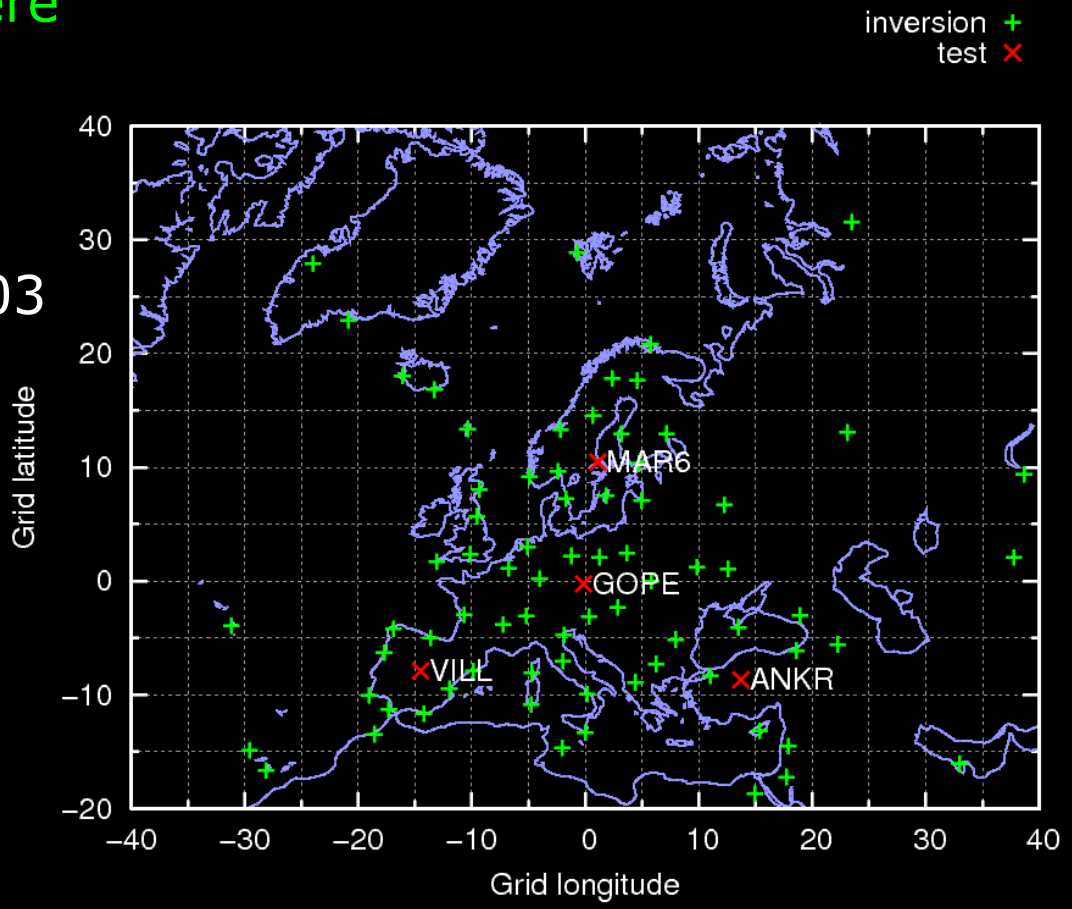
Data

A set of dual frequency receivers is chosen:

- 4 receivers are taken as test receivers
- the others are used to create the image of the ionosphere

The study covers
all 2002 and
21 Oct to 4 Nov 2003



Acknowledgements :

- IGS and EUREF receiver data
- NGDC coastline data

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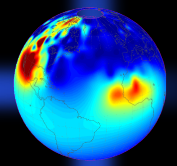
Methods



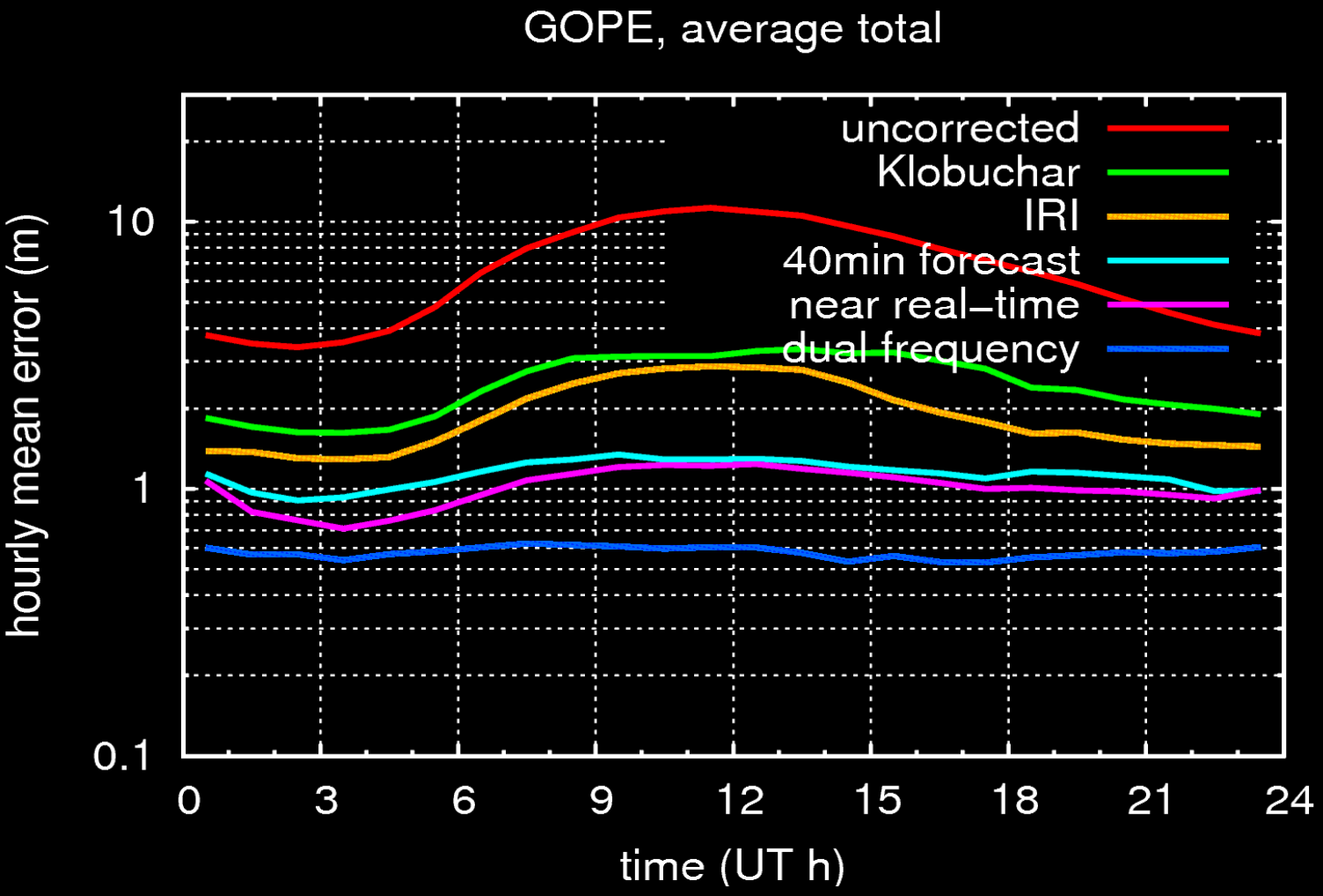
5 single frequency positions :

- no correction
- Klobuchar model
- IRI 2001 model
- MIDAS predicted
- MIDAS near-real-time

are compared to the dual-frequency (with phase-filtering using P1, P2, L1 and L2 observables) benchmark.

i n v e r t

Results : average



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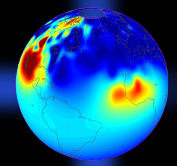
Results



The differences between MIDAS near-real-time and the dual-frequency benchmark are due to :

- space and time sparsity of the data
- lack of phase filtering

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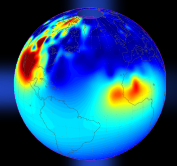
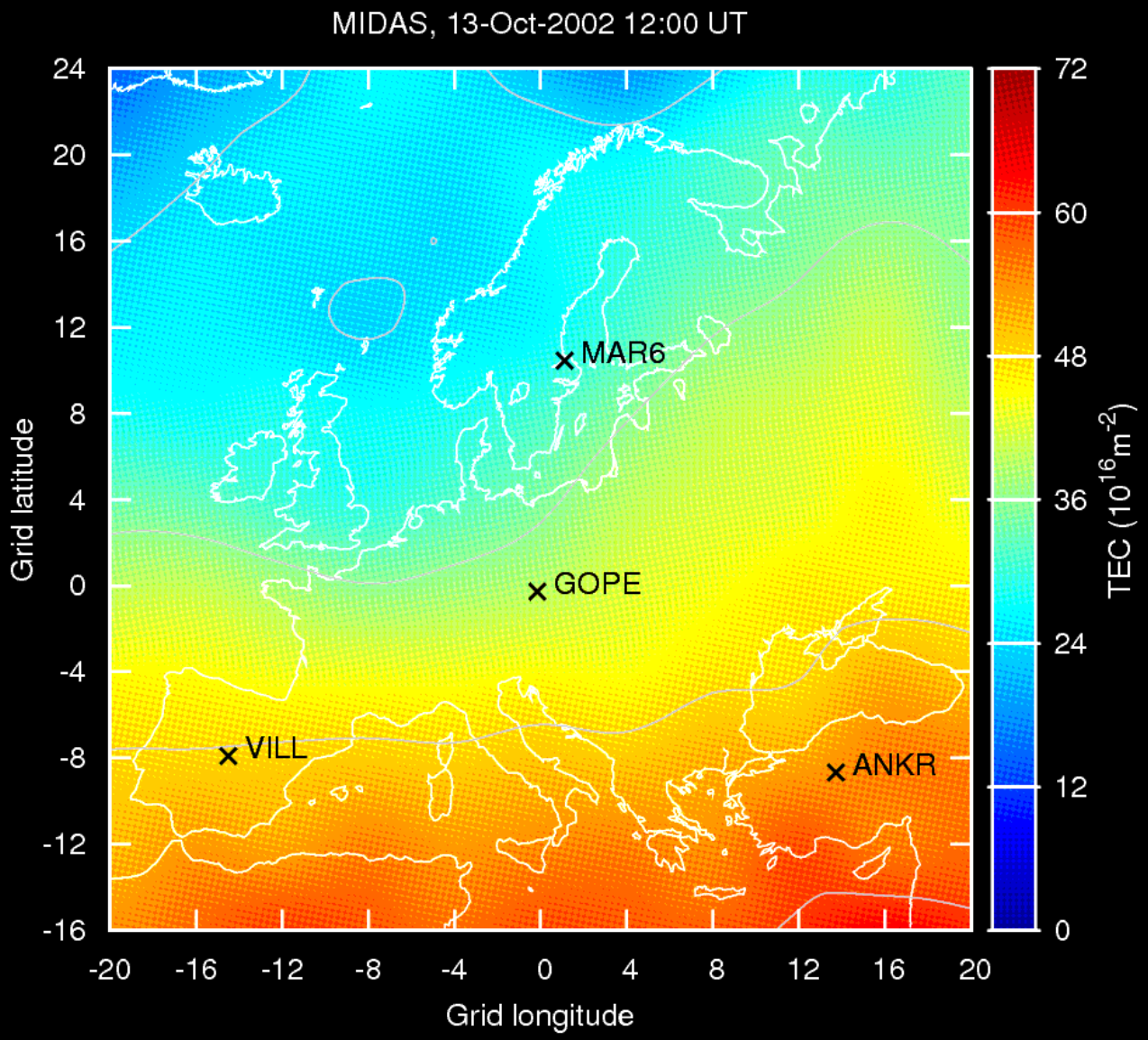
Results : quiet day





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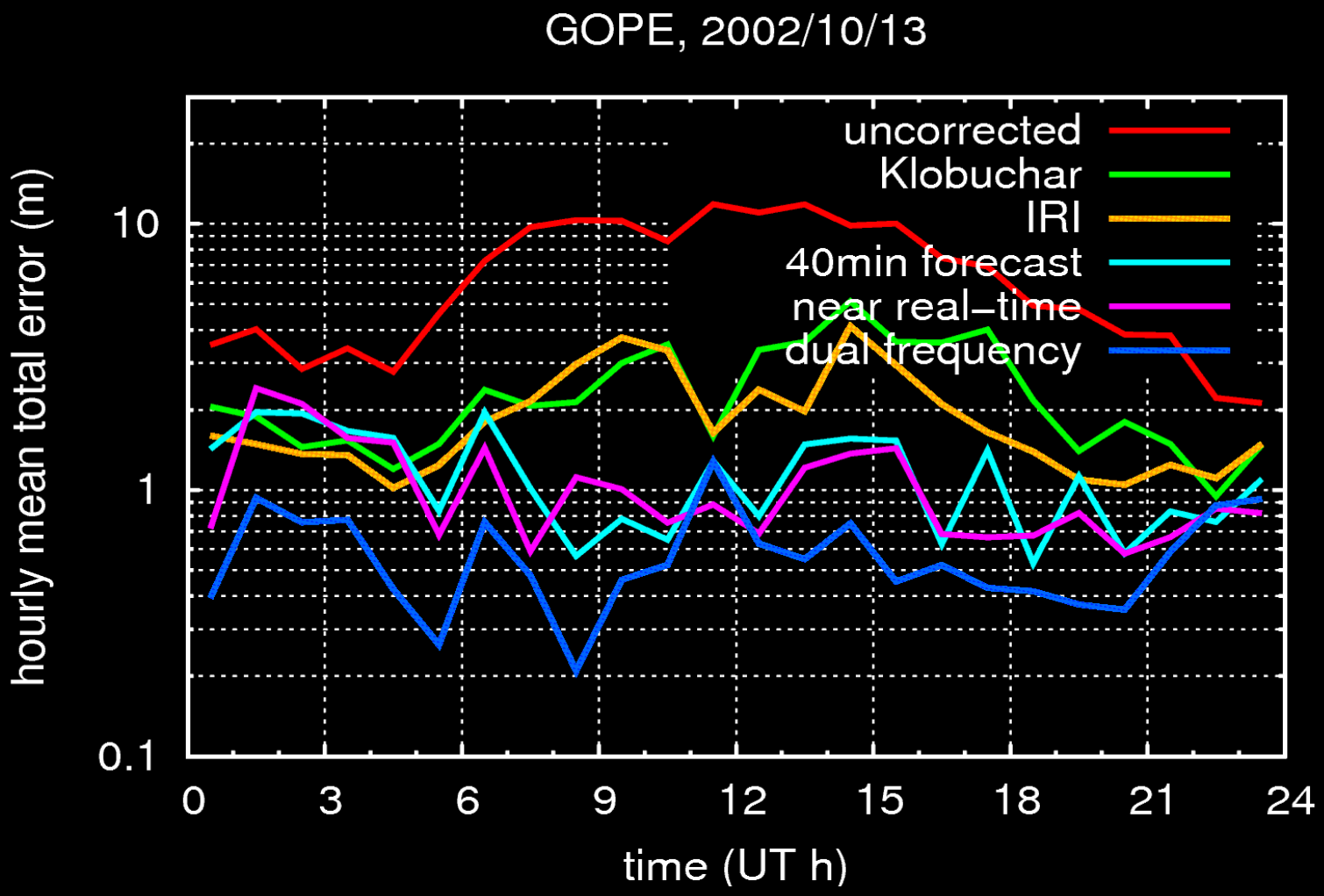
Results : quiet day



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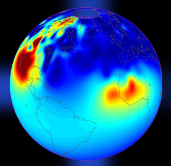
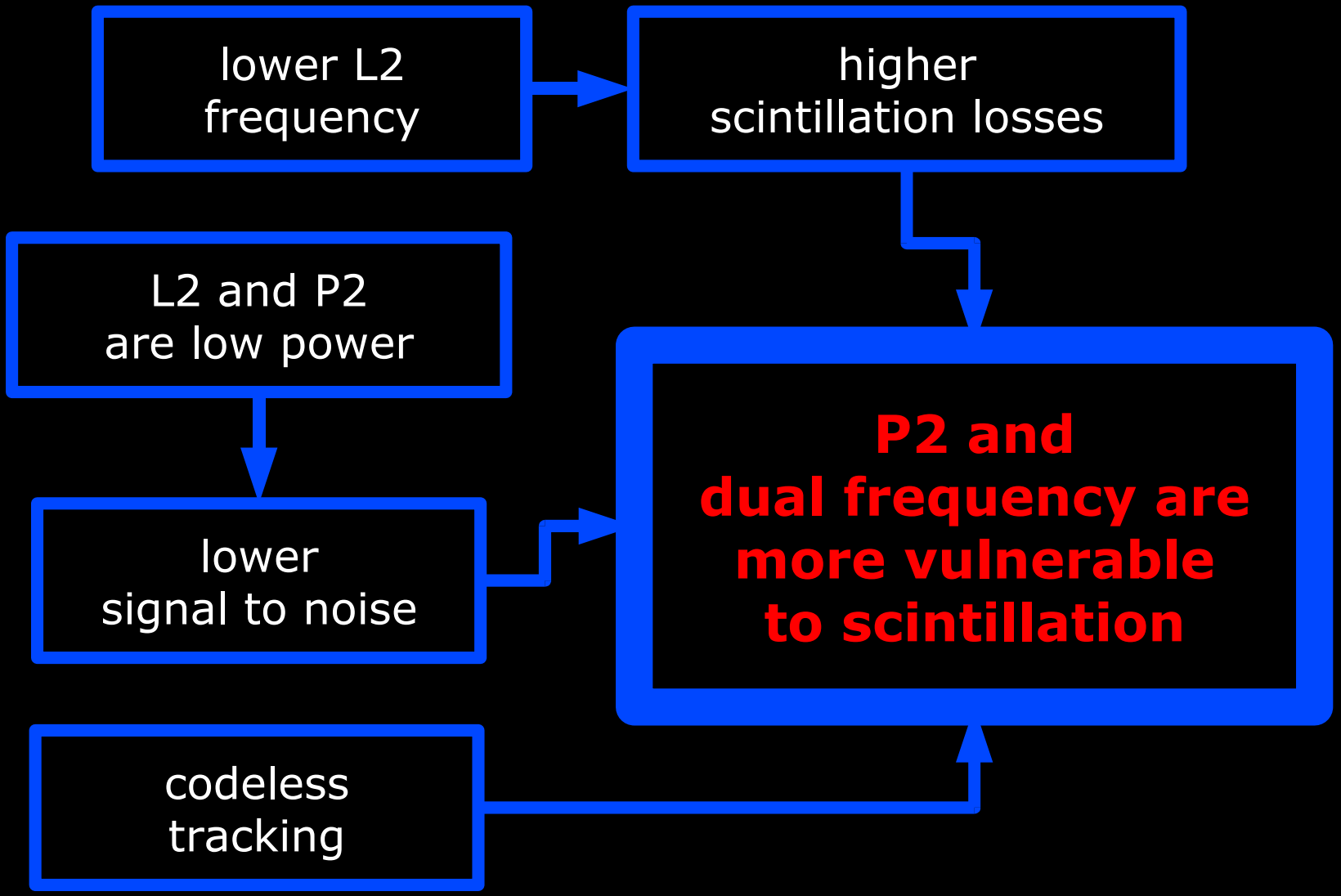
Scintillation





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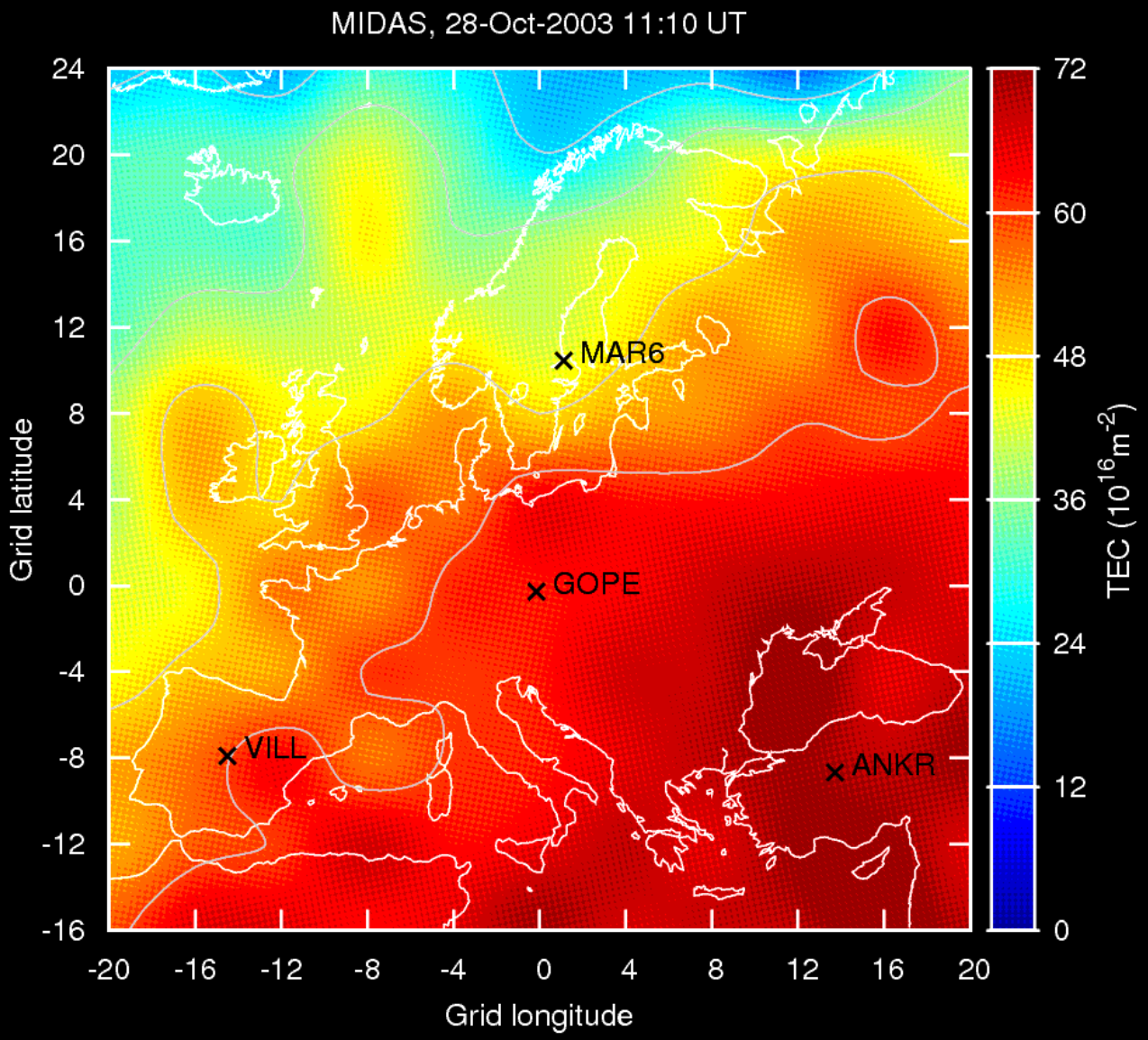
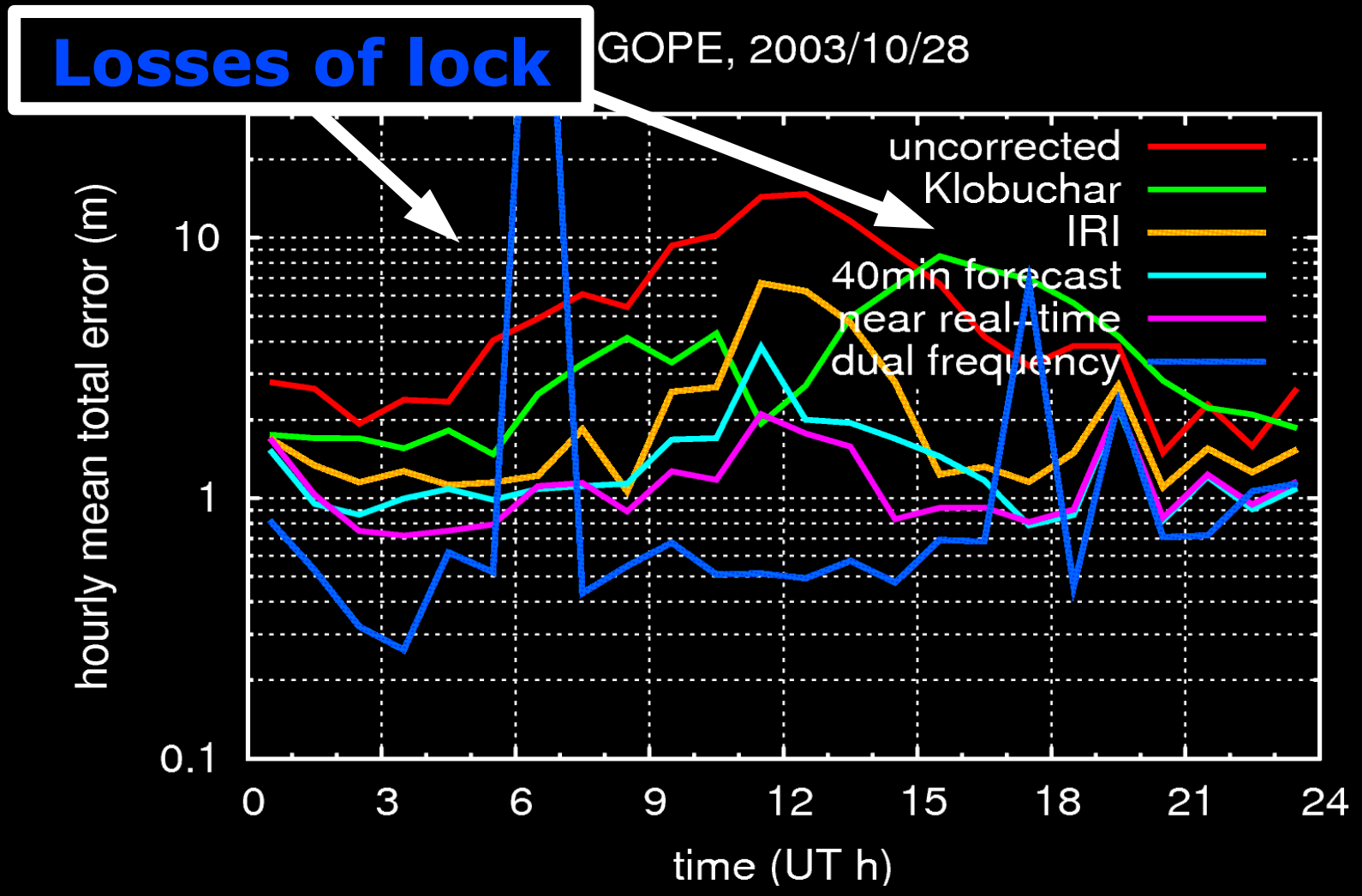
Results : storm



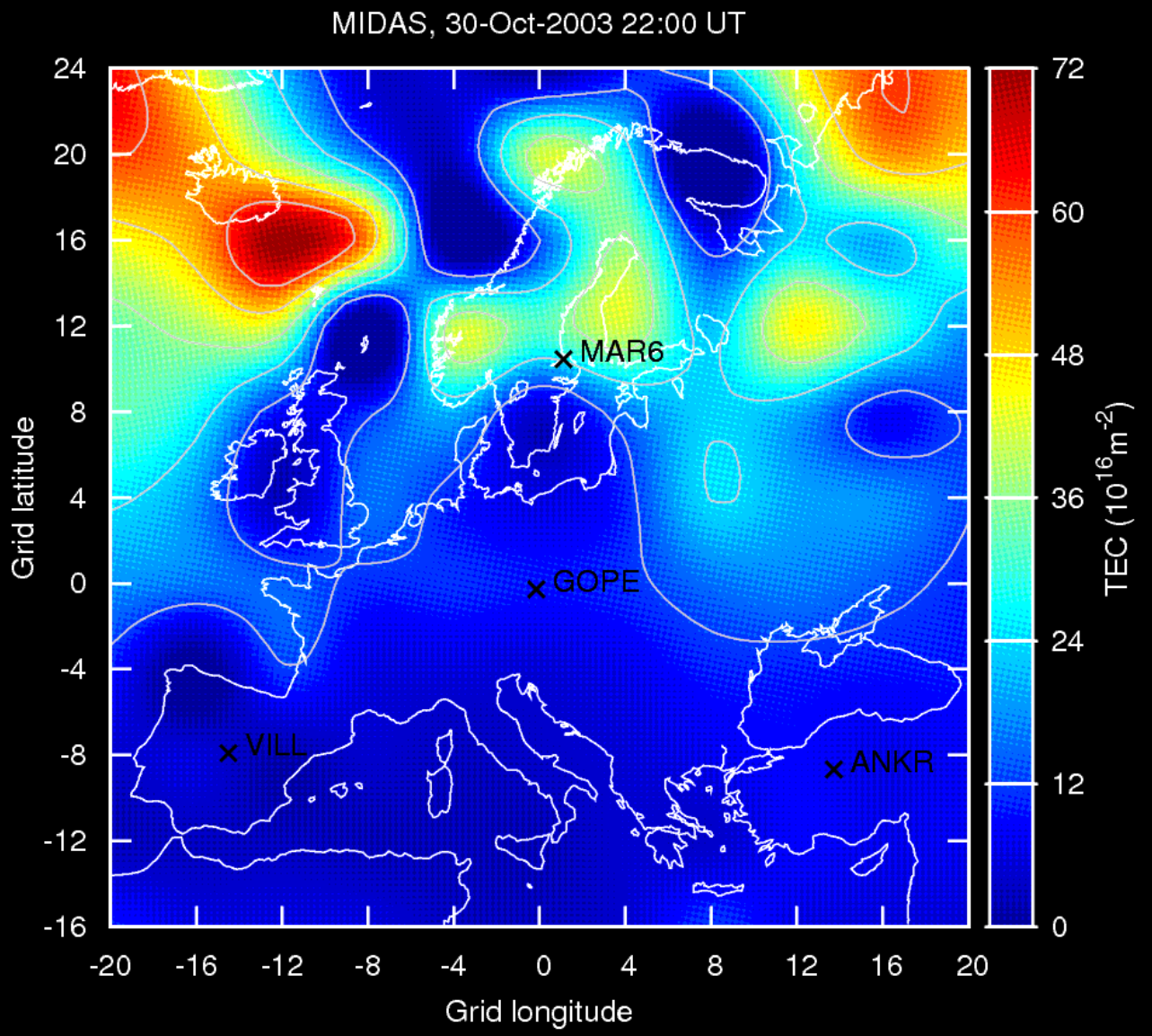
invert

Results : storm



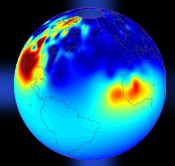
invert

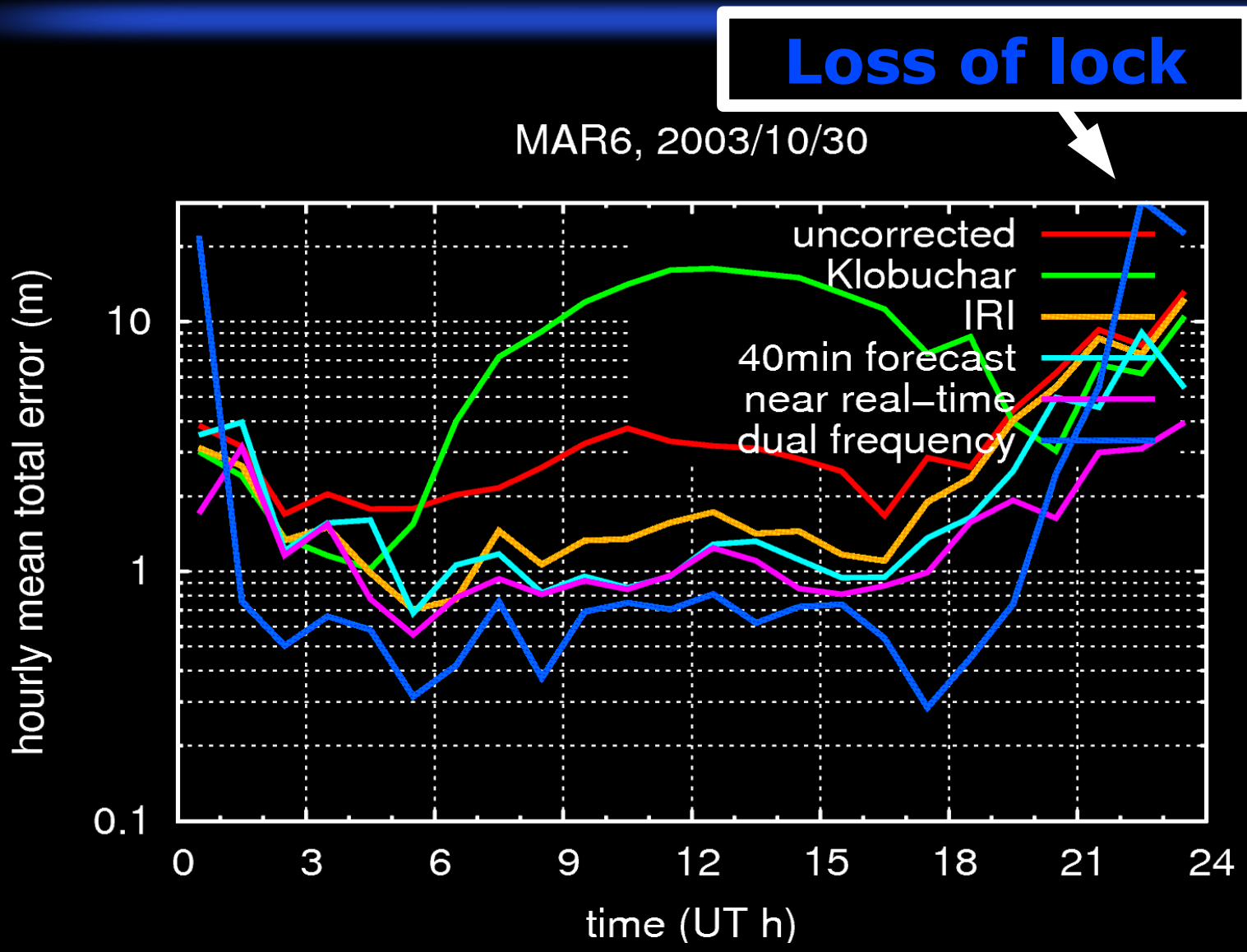
Results : storm



invert

Results : storm





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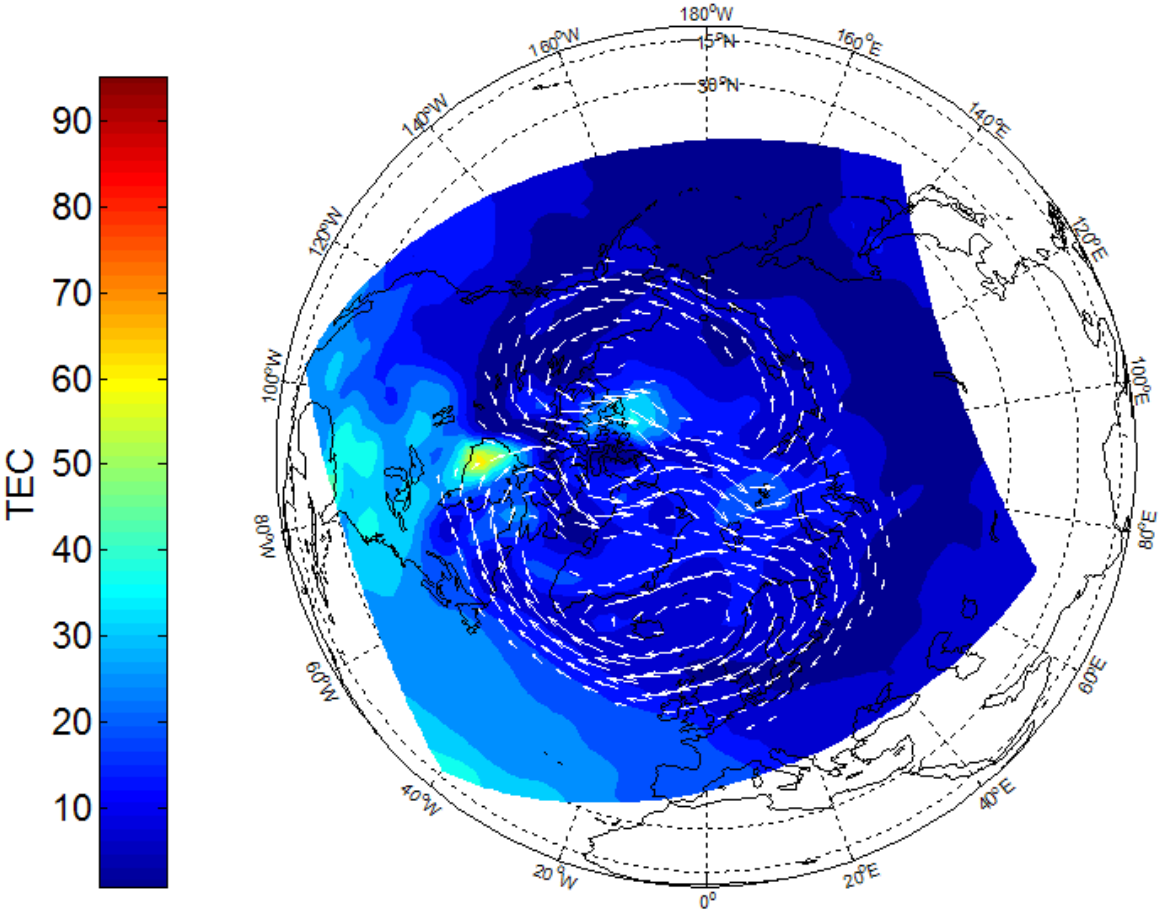
Results : storm



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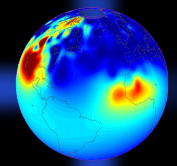
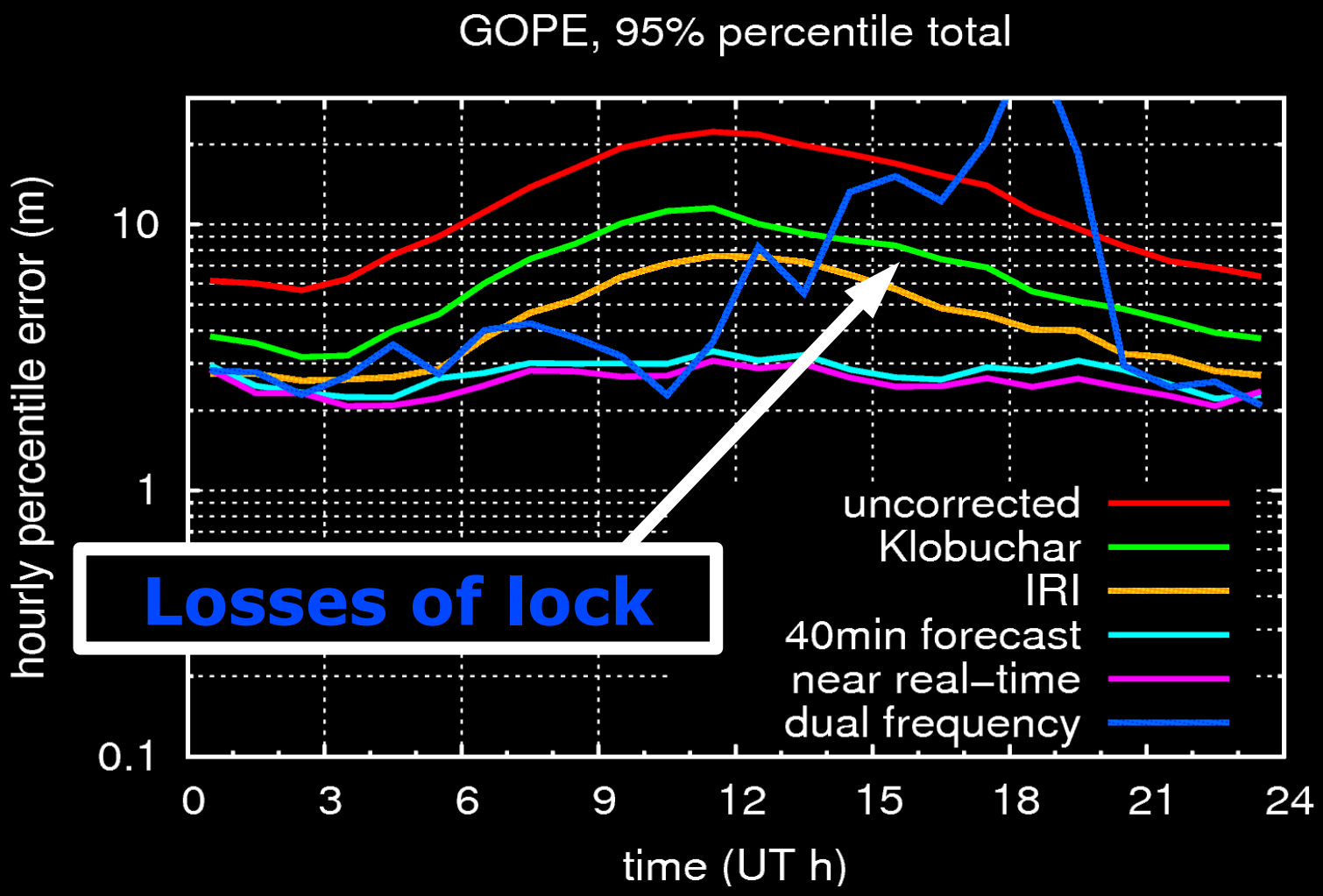
Results : 95% confidence





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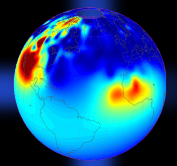
Conclusion



Accurate and reliable predicted MIDAS corrections for real-time use are available :

http://people.bath.ac.uk/da224/rti/

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Any Questions ?

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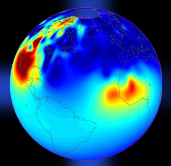
http://people.bath.ac.uk/da224/

References



- Meggs RW, Mitchell CN (2006) A study into the errors in vertical total electron content mapping using gps data. Radio Science 41, DOI 10.1029/2005RS003308

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